STATISTICAL INVESTIGATIONS OF STATUTORY HOLIDAY EFFECTS ON TRAFFIC VOLUMES

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ABSTRACT:

Traffic volume fluctuates from time to time and location to location, resulting in significant variations in demand. Specifically, the increases of travel during statutory holiday periods are substantial and some of the resulting critical traffic problems have been reported. An understanding of this substantial traffic volume variation can assist transportation agencies in developing practical countermeasures in such various aspects as: traffic control plan, signal timing, safety programs, traffic volume monitoring and prediction. Unfortunately, literature regarding holiday traffic has been limited, and no effort has been found to statistically examine the significance of traffic volume changes due to holiday effects. Based on past 20 years of data collected by permanent traffic counters (PTCs) on highways of Alberta, Canada, holiday effects on road traffic are first visualized in this paper through graphical presentations. Then, the non-parametric Wilcoxon matched-pair test is chosen to test the variation characteristics of normal flow, the Friedman method is applied to investigate the holiday effects on weekly and daily traffic, and the hourly volume pattern changes are examined by a combination of Chi-square and Binomial tests. The test results are consistent in general, revealing that holidays substantially contribute to the variability of traffic. The weekly volume variations during holiday periods are significant in many cases, the holiday effects on daily and hourly traffic are evident, and the directional holiday traffic peaking features are strong. Meanwhile, general identifications of the holiday affected days for different types of roads are also provided. At the end of this paper, potential implications of these findings are discussed.

INTRODUCTION

Traffic volume fluctuates from time to time and location to location, resulting in significant variations in demand. The traffic volume variations are usually affected by the social and economic activities of the area being served by a highway (TRB 2000) and these effects can be particularly significant during holiday periods. In the United States, the Bureau of Transportation Statistics (2003) reported that the number of long distance trips increases by 54% during the Thanksgiving period and about 91% of this travel is by personal vehicle. In Canada, Liu et al (2005) found that the traffic growth during most Canadian statutory holiday periods is substantial. Moreover, Wright et al (1997) stated that the larger contributors to traffic variability are weekend days rather than weekdays and "all holiday period" days rather than "non-holiday period" days.

An understanding of this substantial traffic volume variation due to holiday event is important to many transportation agencies. Although the available literature regarding holiday traffic has been limited, the issues it identified are critical. Nakamura (1994) and Yai (1995) studied the holiday traffic in Japan and concluded that significant traffic volume variations between weekdays and holidays could cause serious problems in roadway planning and operations. In practice, Farey (1988) presented a real holiday traffic dominating highway design case in the United Kingdom. From the safety point of view, Arnold et al. (1988), Bell (2001), Emmel and Aber (1992), and Liu and Chen (2004) recognized that more crashes occurred on highways during holiday periods. Such agencies as the Pennsylvania Department of Transportation and Tennessee Department of Safety have implemented some countermeasures in anticipation of the heavier-than-normal traffic with the intention to improve road safety. However, the implementation periods varied based merely on local agencies' judgments. Holiday events also play a role in traffic monitoring practice, addressing missing or extreme values can create serious issues. The missing values and outliers can be imputed following a given agency's procedures; however, the attempt to identify rogue observations without considering holidays may result in misidentification and misinterpretation of values (Redfern 1993).

The literature clearly indicates that holiday traffic trends are important. The recognition of traffic characteristics due to holiday effects can assist in developing practical countermeasures in various aspects such as traffic control plan, signal timing, safety programs, traffic volume monitoring, imputation and prediction. However, one challenge is that the holiday effects may not only take place exactly on holidays. Very likely holiday effects would cover longer periods including days adjoining holidays. Moreover, the effects of various holidays on different types of roads may vary. Since no literature has been found in this regard, the main objectives of this paper are to graphically visualize the holiday effects on traffic volumes in a week wide period. Then, for each direction of different types of roads, the significance of weekly, daily and hourly volume changes during various holiday times is investigated using non-parametric hypothesis test methods. At the end of this paper, potential implications of the findings from this study are also discussed.

BACKGROUND INFORMATION

Holidays Considered

In order to assess the holiday effects on traffic volume variations using Alberta's data, it is first necessary to identify which holiday occasions are observed in that province. According to the

Canadian Heritage Department, there are 10 national statutory holidays throughout Canada. In addition, each province has its own holiday(s), which are typically observed on Mondays during the summer months. According to Calendar Updates (2003) and Globalseek (2004), the 12 national and provincial holidays observed in Alberta are listed in Table 1.

These 12 holidays basically belong to two categories: long weekend holidays and specific-date-holidays such as New Year. Regarding each of the long weekend holidays, traffic characteristics tend to be consistent since every year they happen on the same day. However, the volumes of traffic are inclined to vary remarkably during holidays falling on specific dates when the dates occur on different days of the week. Because most specific-date-holidays occur in cold seasons when traffic volumes are relatively low and traffic operating situations are less critical, this study aims mainly on weekend holidays. Canada Day is a special case. On one side it occurs in summertime and has substantial holiday traffic; therefore, the holiday traffic analysis is needed. On the other side, because it is officially observed on July 1st and can fall on any day of the week, traffic characteristics of this holiday vary considerably – depending on whether Canada Day results in a long weekend. In order to reduce the research complexity and focus on peaking traffic, in this study, Canada Day is investigated only when it furnishes long weekends.

Study Data

The data employed in this study was collected by permanent traffic counters (PTCs) on major highways in Alberta, Canada over the past 20 years. Due to the fact that holiday traffic characteristics are different for various types of roads, the PTCs were first classified into groups based on driver population as proposed by Sharma et al. (1986). This method distinguishes itself from others by considering the trip purpose and the trip length distribution as well as temporal volume variations when grouping highways by function. The main advantage of this classification technique is that it leads to a better understanding of the road user's perspective of a highway's function, hence provides better insights into the holiday travel characteristics. The grouping process resulted in the five classifications representing different types of roads for which study data would be employed. These groups were labeled as commuter (CM), regional commuter (RCM), rural long distance (RLD), recreational (Rec) and high recreational (HighRec).

Based on the consideration of PTC locations and the numbers of available years of data, two PTCs were selected from each road group in this study. As a result, a total of ten PTCs from seven different routes were analyzed. The detailed information of each counter is provided in Table 2. Their monthly variation patterns are shown Figure 1. The distribution for CM roads appears to be relatively flat due to stable traffic flows. The patterns of RCM roads are similar to CM routes, with slightly higher summer traffic. The RLD and Rec groups, however, show higher peaks in summer and lower troughs in winter. The HighRec group has the highest peaks during the summer months.

Analysis Time Period for Each Holiday

It stands to reason that the effects of each holiday would not only take place exactly on the holiday date, but also extend to other adjoining days. A careful examination of the study data revealed that holiday traffic peaking usually starts on one or two days before the long weekend and lasts one or two days afterwards. Therefore, in order to cover the full effects of a holiday, the week in this study consists of the holiday long weekend plus two days before and two days after it. Hereafter, it is called holiday week (Wk_Hol).

The effects of a specific holiday on traffic volumes can be identified by examining the differences of the volumes during the holiday week and those from neighboring non-holiday periods. Therefore, along with the consideration of isolating the effects of normal seasonal variation, the volumes from two weeks before and after the holiday week were chosen for detailed statistical comparisons with the holiday traffic. In this study, the week immediately prior to the holiday week is named as Wk_B1, and the week preceding Wk_B1 is referred to as Wk_B2. Similarly, Wk_A1 and Wk_A2 are defined for the two weekly periods following the holiday week.

VISUALISATION OF HOLIDAY EFFECTS ON TRAFFIC VOLUMES

In order to demonstrate the influences of various holidays on traffic variations over a relatively long period, the directional hourly volumes of the entire 5-week analysis period were plotted for different types of roads. The hourly volumes of each day from the holiday week were contrasted with those of the same days from Wk_B2, Wk_B1, Wk_A1 and Wk_A2, respectively.

Figure 2 illustrates a typical example of holiday effects on a rural long distance road site, 001141, during the Heritage Day period in 2003. This site is located on the TransCanada Highway, between the City of Calgary, which is a large city in Alberta with a population of about 950,000, and the City of Medicine Hat, which is a mid-size city with a population of about 60,000. This site serves a large portion of long distance travel. In comparison to non-holidays, the holiday week traffic in the eastbound direction starts to increase as early as Thursday, peaks on Friday and continues to grow until Saturday. Sunday volumes do not show apparent differences between holiday and non-holiday volumes. The traffic increases again on holiday Mondays, with several high hourly volumes remaining on Tuesday. No difference can be observed on Wednesday. Regarding the traffic peaking in this direction, the possible explanation is that people usually leave their homes and proceed to social and recreational destinations on Fridays to start their vacations, and hence generate substantial traffic increases. Hereafter in this paper, this direction is called outbound (OB).

The holiday effects on the westbound traffic look different. At the beginning of the holiday week, Thursday traffic stays the same as normal days. The volumes show increases on Friday afternoon, and then drops back to normal on Saturday. Sunday traffic is somewhat lower than normal; however, the peaking of traffic on the following holiday Monday is substantial. The slightly higher than normal volumes can still be observed on Tuesday. On Wednesday, the traffic returns to normal. This direction's traffic peaking phenomena can probably be explained by the fact that most people return home from vacation sites on Mondays. Hence this direction is called inbound (IB) in this paper.

For the same holiday period discussed in the preceding example, a typical commuter road presents markedly different patterns, as shown in Figure 3. There was no significant directional difference that can be noted at this example site, 016186, which located near the provincial capital — the City of Edmonton. For both directions, the hourly volume patterns of each working day from Tuesday to Friday remain the same, no matter if the traffic is from the holiday week or not. Regarding the long weekend, holiday Saturday's pattern is similar to those of normal Saturdays. However, the traffic in both directions on Sunday and Monday markedly decreased, especially for Monday, when the morning and evening peaks vanish.

The effects of various holidays on these as well as other types of roads were conceptually similar to the examples shown in Figure 2 and 3, but the exact influences might vary in different cases. This is carefully examined using standard statistical methods in the following section.

STATISTICAL INVESTIGATIONS OF HOLIDAY EFFECTS

The data visualization clearly shows substantial holiday effects on traffic volumes, however, it does not provide sufficient proof to identify what kind of traffic on which day can be considered statistically affected. Therefore, a number of statistical analyses were carried out based on historical data in order to investigate the variation characteristics of different types of traffic during various holiday periods. Since the holiday effects are generally observed over several days, the hourly and daily volumes from different days of the week, as well as the weekly volumes were investigated in this study. Depending on the availability of annual traffic data over a period of many years, two PTC sites from each road group were utilized to carry out the statistical investigation.

The weekly volumes and the volumes from the same day of different weeks were assumed to be independent outputs from different experiments; therefore, the sample data could be examined to determine if they belonged to the same population. In order to do this, parametric hypothesis test methods (Montgomery and Runger 2003, Shirley and Stanley 1991) were first considered in this analysis by checking the appropriateness of their use for this purpose. Unfortunately, based on the results of normality test using SPSS 10.0 software package, it was found that the study data did not always satisfy the basic assumption for parametric methods — that the samples have been drawn from normally distributed populations with equal variances (Wayne 1990). Consequently, the application of parametric methods was not appropriate for this study.

The non-parametric hypothesis test procedures met the needs of this study since they are valid under very general assumptions and no normality is required (Wayne 1990). After careful inspections of various test methods, the Wilcoxon matched-pair test was first chosen to test the variation characteristics of traffic volumes before and after a holiday week, the Friedman method was then applied to investigate the holiday effects on weekly and daily volumes. Finally the hourly volume pattern (distribution) changes were examined by a combination of Chi-square test and Binomial test. The 95% confidence level was applied to all cases.

Traffic Volume Variations Before and After Holidays

It was desirable to understand the variations of non-holiday traffic, and hence to isolate the holiday effects on traffic volumes from the influences due to other factors such as seasonal changes. Therefore, for each type of road, the variations of traffic in Wk_B2, Wk_B1, Wk_A1 and Wk_A2 were first investigated during various holiday periods in this study. For each case, the following comparisons were conducted for the directional weekly volumes: Wk_B2 versus Wk_B1, Wk_A1 versus Wk_A2, Wk_B1 versus Wk_A1, and the average weekly volume of Wk_B2 and Wk_B1 versus the average of Wk_A1 and Wk_A2. The weekly volumes were studied because they are less likely to be affected by occasional factors such as weather and accidents as compared to daily and hourly volumes.

Comparisons were carried out using the Wilcoxon matched-pairs method (Wayne 1990). This method is a counterpart in non-parametric rank statistics to the parametric matched-pair t-test and involves two columns with paired data in each row. The test conclusion is based on the differences between pairs of observations as well as the directions of differences. In this study, two target weekly volumes from a specific holiday in the same year were first paired, while the

paired weekly volumes from year to year made up the sample population. Because only the differences of paired volumes in the same year contributed to decision-making, yearly volume variation interferences were removed.

Test results led to the understanding of the variation characteristics of non-holiday traffic flow near various holiday periods. It was found that the non-holiday traffic was usually stable during the periods two weeks before the holiday week or two weeks after it. That is, the traffic from Wk_B1 and Wk_A1 were similar to that from Wk_B2 and Wk_A2, respectively. However, the differences of volumes prior to and after holidays, especially for those signifying the beginning or ending of good driving seasons, were significant at 95% confidence interval in most cases for the roads located in rural area. For example, the traffic after Canada Day (July 1st) was significantly higher than that before this holiday at all study sites. In contrast, the traffic after Labor Day, which is the last holiday before the end of summer and the reopening of schools, was significantly lower than before. Heritage Day occurs in the middle of summer. Therefore it represented the situation when the differences of traffic before and after this holiday were usually not significant at 95% confidence interval.

Investigation of Holiday Effects on Weekly Volumes

The typical variation patterns of weekly volumes during the analysis periods are illustrated in Figure 4, where the relative volumes (the ratio of weekly volume to annual average daily traffic) are plotted as a function of study weeks (Wk_B2, Wk_B1, Wk_Hol, Wk_A1 and Wk_A2). Figure (a) shows that the northbound weekly volumes for a regional commuter road site of 043221 are relatively stable before, during, and after the Alberta Family Day week. For the same road site, Figure (b) exhibits a different case in which the traffic in the southbound direction during Good Friday periods seems higher than those from the non-holiday weeks. Figure (c) and (d) demonstrate the unstable traffic conditions on two recreational sites throughout the analysis periods. In both cases, it looks like there is more traffic during the holiday weeks. However, Figure (c) shows that, for the site of 001061, the eastbound volumes from Wk_A1 and Wk_A2 after the Canada Day week are higher than those from Wk_B1 and Wk_B2 before it. In regards to the other site of 001025 (Figure (d)), the eastbound traffic after the Thanksgiving Day week is lower than before the holiday with a noticeable decreasing trend.

In order to statistically examine the significance of holiday effects on the weekly volumes, the Friedman test (Wayne 1990) was employed in this investigation. This method is a non-parametric analogue of the parametric two-way analysis of variance (ANOVA), with the objective of determining if a conclusion can be drawn from sample evidence that there is a difference among treatment effects. In regards to the application of this method, for each study site, directional volumes from different weeks (including the holiday week) in the same year were first considered as the data from different treatments in the same block and the historical data constructed the blocks. Then, the data in the same block was ranked from smallest to largest. Next, the rank values for each treatment were summed up. With the principle that either small or large ranks should show a “preference” to a particular treatment, the decision was finally made by comparing the Freidman statistic with appropriate critical values. Since the ranking process of this method only considered within-block observations, the yearly volume variations did not interfere with analysis results.

For the cases when the Friedman test result showed at least one difference among the treatments, a multiple comparison procedure (Wayne 1990) was carried out to determine where the difference(s) actually resided. A firm conclusion that the holiday effect was significant was

only drawn when the volume from the holiday week was consistently higher or lower than the normal traffic before and after the holiday week, and no significant difference was detected among the normal traffic.

This test procedure was applied to determine the effects of various holidays on the directional weekly volumes for different types of roads. Test results showed that the weekly volumes during holiday periods of Good Friday, Victoria Day, Heritage Day and Thanksgiving Day were always significantly higher than the non-holiday traffic at 95% confidence level. The effects of Alberta Family Day were insignificant for commuter, regional commuter and rural long distance roads because this holiday occurs in February when the weather is cold. However, its effects were significant for recreational and high recreational roads. The travel changes during Canada Day and Labor Day weeks were different from those during other holidays. The volumes of Canada Day week were significantly higher than those before this holiday, but generally similar to those afterwards. On the contrary, the Labor Day week traffic was usually similar to the prior weeks, but significantly higher than those after this holiday. With regards to the road types, the weekly volumes from high recreational road sites were affected the most. For commuter routes, it may be noted that the traffic was only significantly affected by Heritage Day at 95% confidence level.

Investigation of Holiday Effects on Daily Volumes

The variation patterns of daily volumes during the five-week analysis period were also studied carefully and the Friedman method along with the multiple comparison procedure was similarly applied to examine the effects of various holidays on the directional daily volumes of each day of the week, for different types of roads.

It was found that for rural long distance, recreational and high recreational roads, the holiday effects on daily traffic volumes were evidently different for outbound and inbound directions. The traffic from the days at the beginning of holiday weeks, typically Fridays, Saturdays and Thursdays (in some cases) were usually significantly affected in the outbound direction at 95% confidence level. In the other direction, the effects were significant on Mondays and Tuesdays. The directional features of holiday effects could be noticed for regional commuter roads as well, but the affected days were generally limited to Fridays in the outbound direction and Mondays in the inbound direction. The holiday effects on commuter routes were only significant for Monday traffic regardless the direction. The daily volumes of Wednesdays were not affected at 95% confidence level in all cases. It is also worthwhile to mention that for every road type except commuter, the holiday effects in the outbound direction tended to spread over a longer period than those in the inbound direction. This resulted in the directional differences in terms of relative traffic increases. For instance, the maximum of daily traffic growth in the outbound direction from all the study sites was about 120%; however, it soared up to 600% in the inbound direction.

In regards to the effects of different holidays, Alberta Family Day and Good Friday are two special cases as compared to other holidays. The Alberta Family Day falls in wintertime and does not induce any significant changes in travel activities; hence its effects were the weakest among all holidays. The effects of Good Friday were different since Friday became a holiday and traffic started increasing on Thursday in the outbound direction. The fact that the following Monday (Easter Monday) which might or might not be observed by employers explained why the inbound traffic during this holiday usually peaked on multiple days such as Sunday, Monday and Tuesday.

Investigation of Holiday Effects on Hourly Volumes

ITE (1999) recognizes that when each hour of traffic flow is considered over a 24-hour period, there are typically three patterns that can be observed: commuter; partially commuter; and non-commuter. In addition, when no special event interferes, usually the pattern of hourly volumes has strong repeatability. For example, at a specific location, this Wednesday's hourly volume pattern is expected to be similar to the pattern of previous Wednesday as well as the next Wednesday. However, events such as holidays can alter the hourly volumes in both magnitude and distribution.

Figure 5 illustrates how the hourly patterns change from two weeks before the Heritage Day week to two weeks after by using the Monday hourly volumes from the inbound direction on different types of roads. Figure (a) demonstrates the twenty-four-hourly-volume patterns from the five study weeks in 2003 at the commuter road site of 016186, which is located near the City of Edmonton. The patterns of the four non-holiday Mondays are similar to each other and contain obvious morning and afternoon peaks. On Heritage Monday, however, this typical commuter pattern is transformed to non-commuter when both the morning and afternoon peaks disappear and overall volumes decrease. Based on the 2002 data from a regional commuter site of 001125 (about 40km east of the City of Calgary), Figure (b) provides a partially commuter pattern example with moderate peak traffic increases on non-holidays. It is observed that the peaks become vague on Heritage Monday, and the majority of traffic shifts towards afternoon travel. Finally, highways with a non-commuter travel pattern, such as the high recreational site of 093001 (Figure (c)) in the Banff National Park, usually serve a high proportion of long distance and recreational traffic with a minimal peaking at about noon. On Heritage Monday, though the general travel pattern remains non-commuter, all of the volumes in afternoon hours increase significantly. Meanwhile, the morning hourly volumes decrease slightly.

The holiday effects on hourly volumes such as shown in Figure 5 were investigated by using a combination of the Chi-square and Binomial tests. The Chi-square test is one type of goodness-of-fit test that has been widely used. This test statistic results from a comparison of expected and observed frequencies (Shirley and Stanley 1991). In this study, for every road site, the directional twenty-four-hourly-volume pattern of each day during the analysis periods was considered as one empirical frequency distribution. Each hour's volume in a distribution represented the frequency of independent vehicle events occurring at that hourly interval. The pattern of the day in the holiday week was then considered as the distribution of observed frequencies, and the average pattern for the same day from non-holiday weeks was considered as the distribution of expected frequency. Hence, the Chi-square test was applied to examine the change of hourly volume patterns for each day of the holiday week. In addition, the patterns from non-holiday periods were also compared among each other.

The Chi-square test only examined the holiday effects in one dimension of an individual year so that the results were less convincing. Therefore, in order to develop adequate confidence from historical data as the other dimension, the Binomial probability test (Wayne 1990) was used to examine the occurrence of yearly significance. Since the effects of a holiday in a single year are a make-or-break situation that is either significant or insignificant, the number of significant observations over years was considered to obey the Binomial Distribution. Then, in order to test

if the significant observation is due to the holiday effects or simply due to chance alone, the probability parameter p was set to 0.5. Therefore, with the sample size being the number of years, it could be concluded whether the holiday effects were significant at 95% confidence level from the table of Binomial probability distribution.

Test results of hourly volume variations further confirmed the findings from daily volume investigations. However, the hourly patterns were more sensitive to holiday events. The effects of various holidays were generally significant at 95% confidence level on the hourly volumes of Fridays, Saturdays, Sundays and Mondays in the outbound direction. In the inbound direction, significant effects on hourly volumes were noted for Sundays, Mondays and Tuesdays. The significant holiday effects varied on other days except Wednesday, which was not affected in any case. The Alberta Family Day, though its effects on traffic for recreational and high recreational roads were similar to other holidays, only significantly affected Monday hourly volumes in either direction for commuter, regional commuter and rural long distance roads. Commuter routes were special as compared to other roads types, since only the Monday hourly volumes were significantly altered during most holiday periods.

SUMMARY OF CONCLUSIONS

The effects of various holidays (observed in Alberta, Canada) on traffic volumes are tested in this study using standard statistical methods, namely, Wilcoxon test, Friedman test along with a multiple comparison procedure, and the combination of Chi-square and Binomial test. The 95% confidence level was applied to all tests, and the test results were presented in previous sections. It is found that various holidays affect weekly, daily and hourly volumes differently, and the effects are different for outbound and inbound directions. The traffic from the days at the beginning of holiday weeks, typically Fridays, is usually significantly affected in the outbound direction at 95% confidence level. In the other direction, the effects are significant on the days at the end of holiday weeks featuring Mondays. In general, the effects of holidays during spring, summer and fall seasons such as Victoria Day, Heritage Day and Thanksgiving Day, are stronger than winter holidays represented by Alberta Family Day. With regards to the road type, usually the more recreational traffic a road serves, the more days are significantly affected. It is also found that for every road type except commuter, the holiday effects in the outbound direction tend to spread over a longer period than those in the inbound direction. This results in the directional differences in terms of relative traffic increases.

POTENTIAL IMPLICATIONS

Holidays are special events leading to substantial volume variations. A good understanding of traffic characteristics due to holiday effects can significantly assist in a variety of traffic engineering practices and researches. Some typical examples are discussed in this section.

The extensive traffic increases during holiday periods indicate that a monitoring program, especially as used to provide peak traffic information, may result in incomplete or inaccurate data unless it also includes holiday seasons. This is a departure from traffic engineering convention, wherein many agencies do not collect traffic data during or near holiday periods. The results of this study also support the idea of monitoring traffic volumes in both directions instead of just monitoring in one direction and multiplying the result by two.

Data cleaning and imputation are routinely completed before carrying out any traffic analysis. The findings from this study can help in determining the real outliers, hence, guarding

users against inappropriate analysis and misinterpretation of the data. For example, the substantial traffic increases during holiday periods are very likely actual flow, rather than spikes.

Traffic prediction is an important aspect in planning and management, and the future volume is usually predicted based on the historical data in a time series. However, when it comes to special events such as holidays, appropriate considerations are necessary. Because the results from this study indicate that the holiday-affected days vary with respect to different holidays, directions and road types, from the view of traffic analysis, it might be inappropriate to arbitrarily define various holiday periods simply according to a normal calendar.

The effectiveness of signal timing and traffic control plans largely depend on traffic volume and its distribution. Dramatically increased holiday traffic may bring considerable challenges to the road network and can create or magnify road congestion. It is worthwhile to mention that even though most people may be resigned to congested freeways and streets during daily commutes, no one wants to experience traffic congestion during holiday vacations. Therefore, the results from this study may assist researchers in realizing the substantial changes of peak traffic volumes for the upcoming holiday seasons, and hence supporting the system optimization and smoother traffic flows.

Road safety always draws attention and researchers have pointed out that holiday periods are hazardous. A number of models have been developed to build relationships between accident rate and traffic flow. However, no in-depth effort has been made to investigate the contributions of holiday traffic to road safety. Average flows are generally used instead of the volumes at the time of the accidents (Mensah and Hauer 1998), and this leads to questions about the accuracy and reliability of these models. The knowledge of traffic variations characteristics during holiday periods can assist traffic engineers in the interpretation of holiday accident events. Also, the investigation results from this study can enable researchers to accurately relate accidents to the holiday-affected traffic.

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List of Tables and Figures

TABLE 1: Holidays Observed in Alberta, Canada

Holiday	Observing Date
New Year (NY)	January 1st, when it falls on a Saturday or Sunday, the next working day is considered a legal holiday.
Alberta Family Day (ABF)	The third Monday of February. It is recognized as a general holiday under the Alberta Employment Standards Code.
Good Friday (GFD)	Occurs between March 20th and April 23rd on the Friday before Easter.
Easter Monday (EMD)	The Monday following Easter.
Victoria Day (VIC)	The first Monday proceeding May 25th.
Canada Day (CND)	July 1st. If it falls on a Saturday or Sunday, the next work day is considered a legal holiday.
Heritage Day (HRT)	The first Monday of August. This day is a civic holiday in all Canadian provinces excluding Quebec, and it is called Heritage Day in Alberta.
Labor Day (LBD)	The first Monday of September in both Canada and United States. It traditionally signals the end of summer vacation across the country.
Thanksgiving Day (THX)	The second Monday of October.
Remembrance Day (RMR)	November 11th, commemorates Canadians who have died in military service.
Christmas Day (XMS)	December 25th. If it falls on a Saturday or a Sunday, the next working day is considered a legal holiday.
Boxing Day (BXD)	December 26th. If it falls on a Saturday or a Sunday, the next working day is usually considered a legal holiday.

TABLE 2. Information of Study Counters

Road Type	PTC Site	Location	Available Years of Data
Commuter	002181	AIRDRIE, 4.6 km south of Highway 2 & 567	15
	016186	EDMONTON, 1 km west of Highway 16 & 21	8
Regional Commuter	001125	STRATHMORE, 2.8 km east of Highway 1 & 24	7
	043221	CARVEL CORNER, 0.8 km north of Highway 16 & 43	11
Rural Long Distance	001141	BASSANO, 1 km west of Highway 1 & 56	12
	003061	MACLEOD, 2.6 km west of Highway 2 & 3	12
Recreational	001025	CANMORE, 9.62 km east of Highway 1 & old 1A	7
	001061	COCHRANE, 1.5 km west of Highway 1 & 22	14
High Recreational	022066	LUNDBRECK, 3.3 km north of Highway 3 & 22	7
	093001	LAKE LOUISE, 6.6 km south of Highway 1 & 93	11

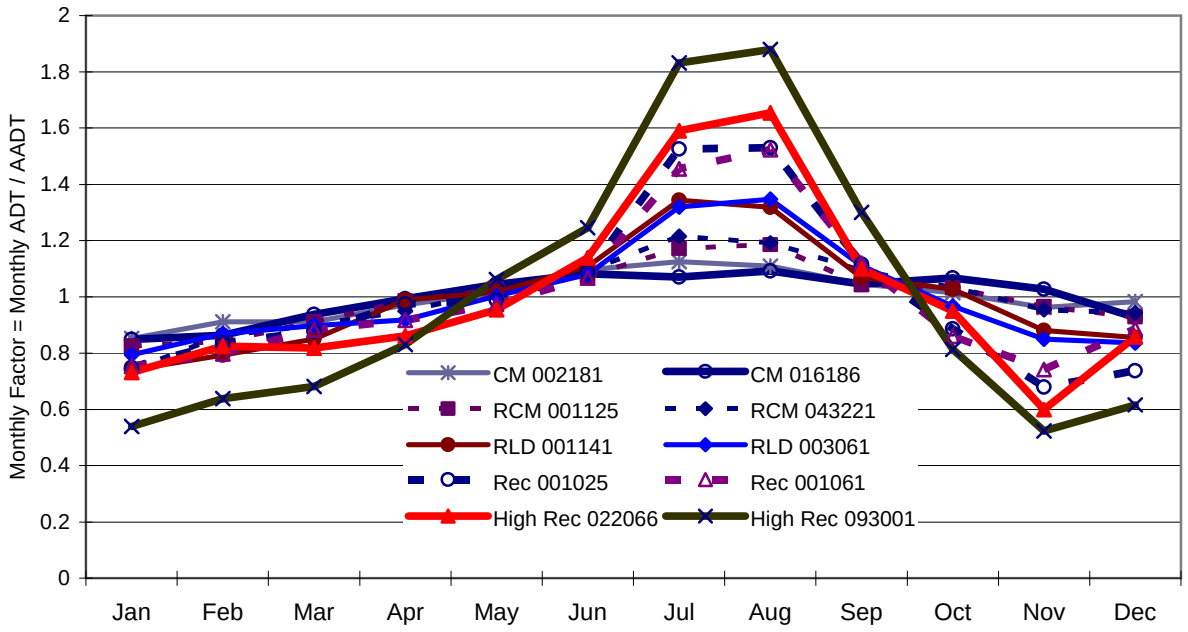
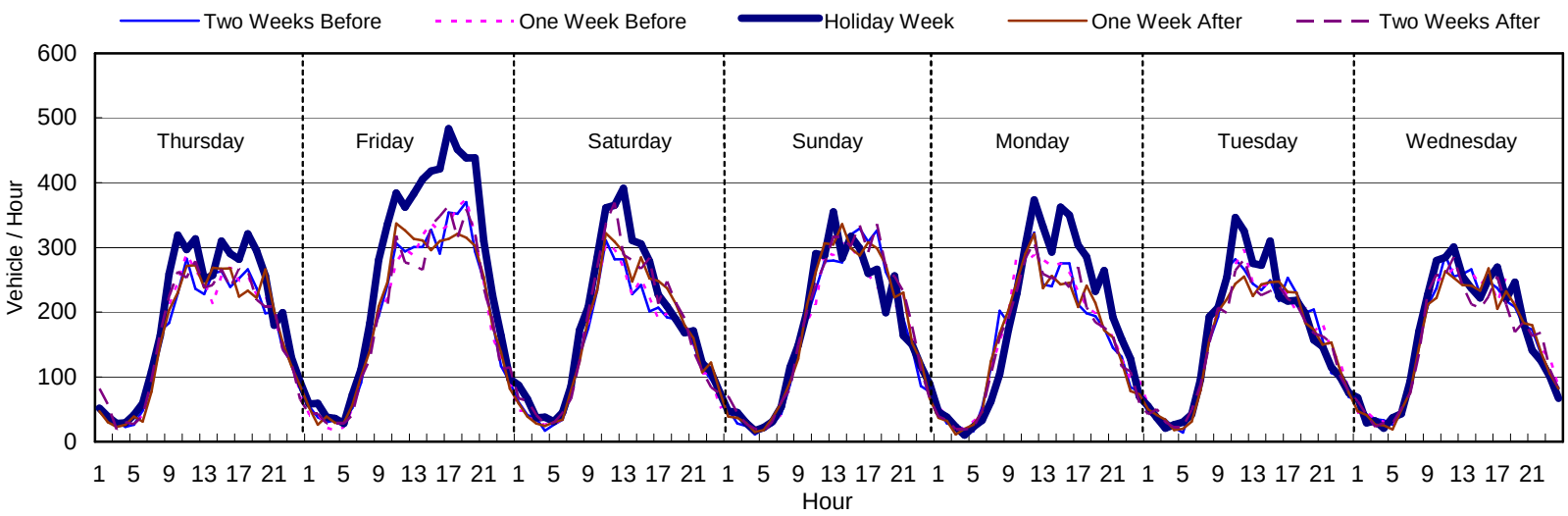
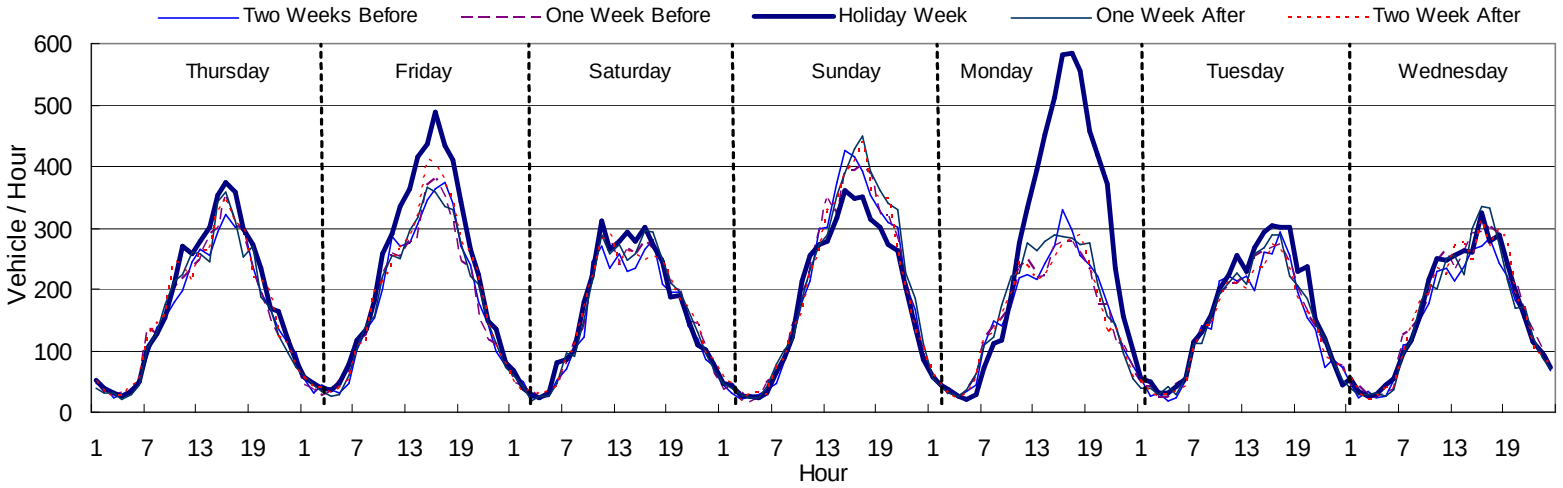


Figure 1. Monthly Variation Patterns of Selected PTCs

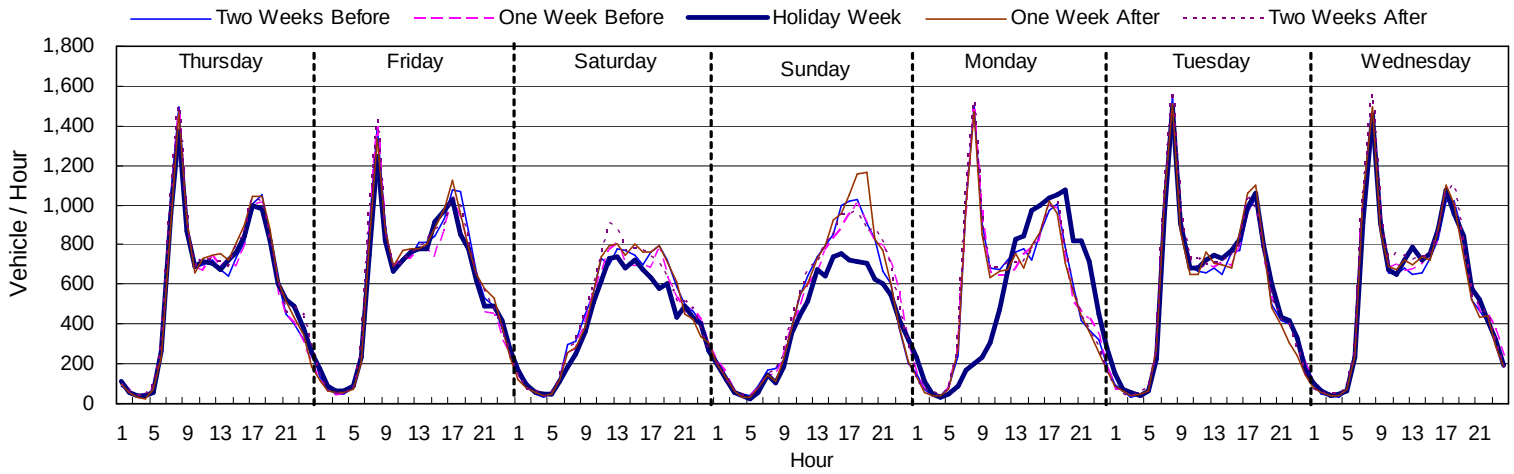


(a) Eastbound Direction (OB)

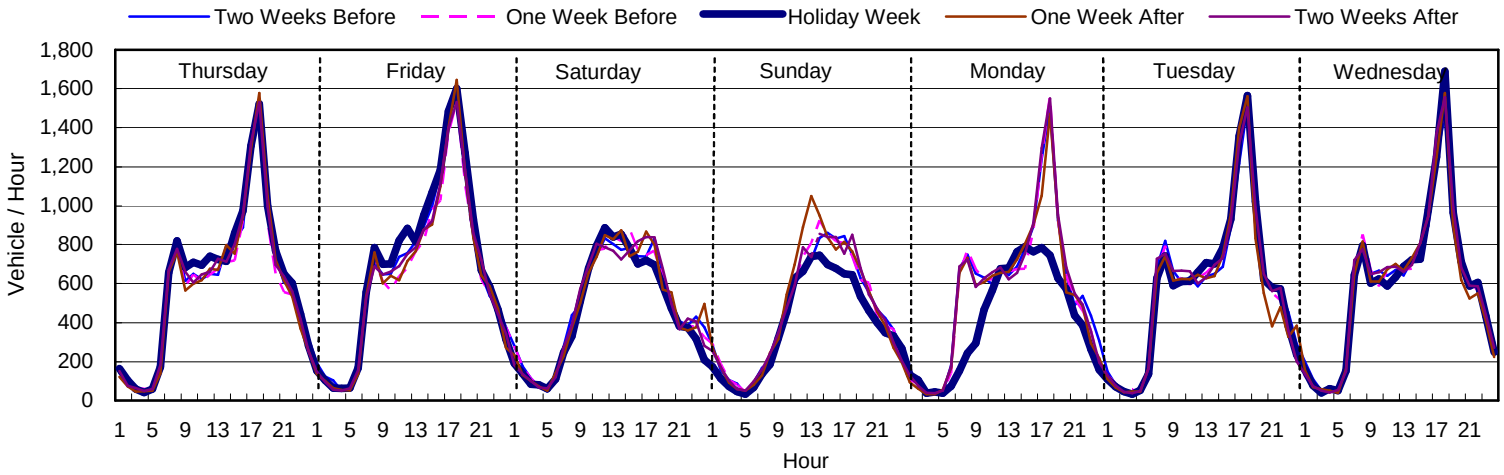


(b) Westbound Direction (IB)

Figure 2 Typical Holiday Effects on the Traffic of a Rural Long Distance Road, 001141, during Heritage Day Period. Data Year: 2003

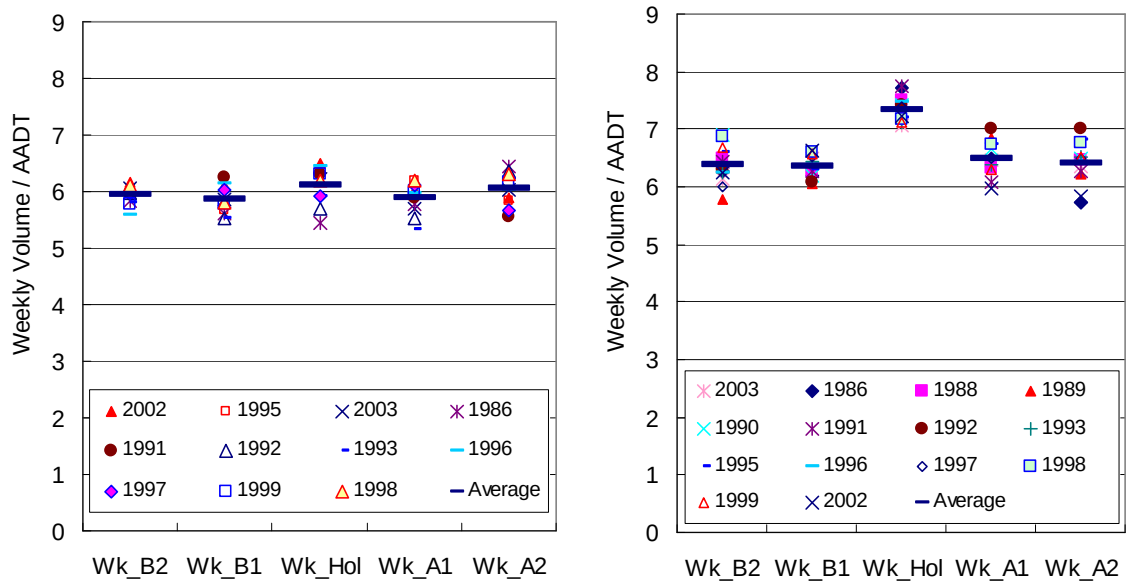


(a) Westbound Direction

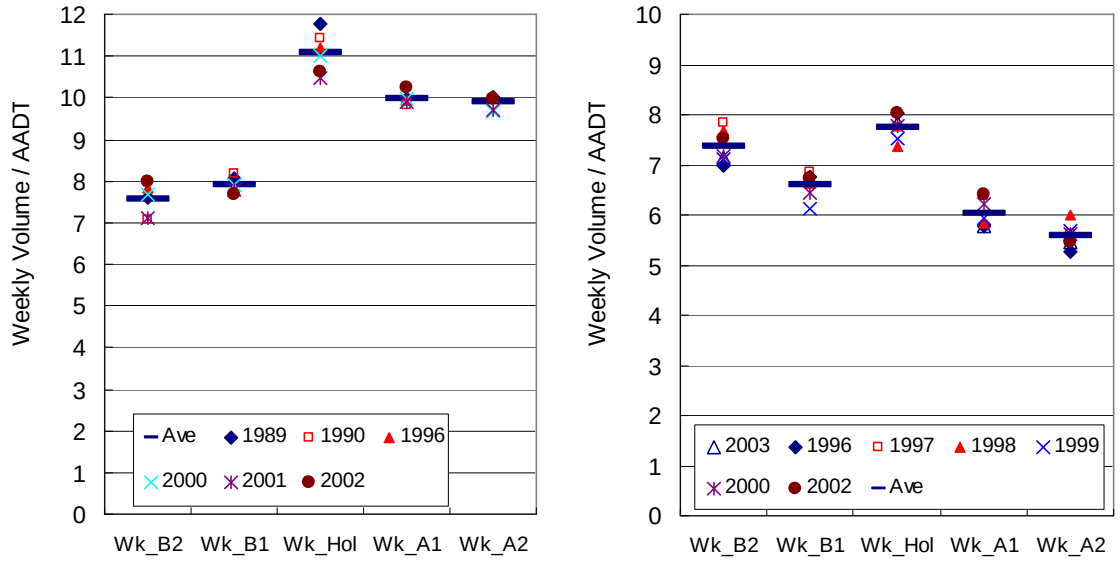


(b) Eastbound Direction

Figure 3 Typical Holiday Effects on a Commuter Road, 016186, during Heritage Day Period. Data Year: 2003



(a) RCM Site, 043221 NB, ABF Period (b) RCM Site, 043221 SB, GFD Period



(c) Rec Site, 001061 EB, CND Period (d) Rec Site, 001025 EB, THX Period

Note:

Wk_B2: two weeks before holiday week
Wk_B1: one week before holiday week
Wk_Hol: holiday week
Wk_A1: one week after holiday week
Wk_A2: two weeks after holiday week

Figure 4. Typical Weekly Volume Variation Patterns during Holiday Periods

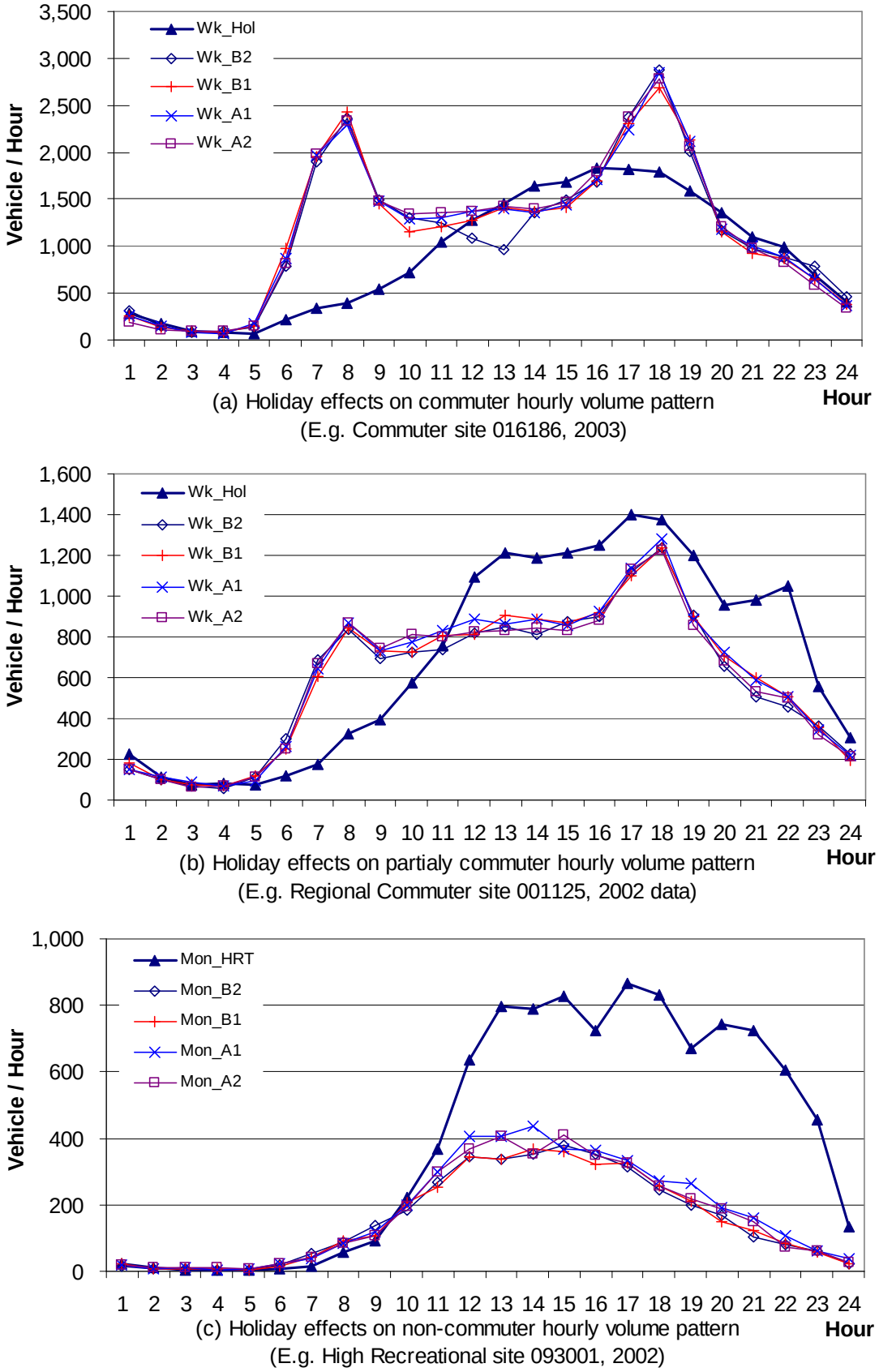


Figure 5. Transformation of Monday Hourly Volume Patterns during Heritage Day Period